Risk in Dam Safety
Canadian Perspective

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Canadian Dam Association

CDA ACB

Washington, D.C. March 18–19, 2008

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Dams in Canada

- Over 14,000 dams in Canada
- Rideau Canal - first system of engineered dams in Canada (1830's)
- Most Small Dams with a Low Failure Consequence

Rideau Canal – 1830's

Jones Falls & Edmund's Weir

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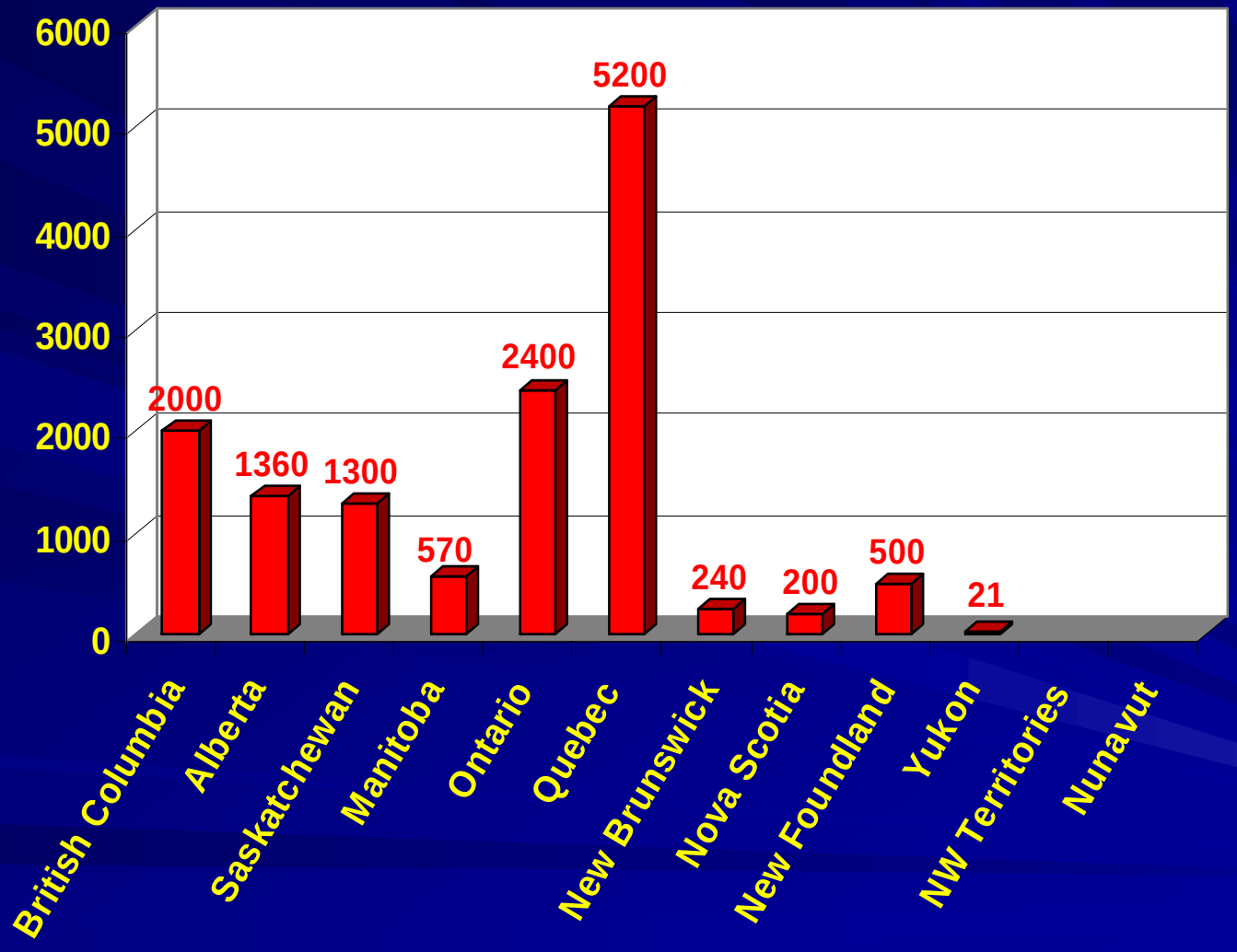
Dams in Canada



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Dams in Canada

- **933 classified as Large Dams by ICOLD**
  - 15 m High
  - 1,000,000 m^3 Reservoir Capacity
  - Unusual Foundations/ Design

Quebec	333
Ontario	149
British Columbia	131
Newfoundland & Labrador	90
Alberta	77
Saskatchewan	44
Manitoba	41
Nova Scotia	37
New Brunswick	16
Territories	15

- **BC Hydro MICA Dam**
  - **243 m Highest Earthfill**
- **Hydro Quebec Daniel Johnson Dam**
  - **214 m Highest Concrete & Reservoir Capacity**

Mica Dam – Columbia River

Daniel Johnson Dam – Manicouagan River

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Canadian Regulatory Framework

1. **Dams Provincially Regulated** (except Boundary Waters)
   - Provincial Responsibility for Licensing Dams and Regulating Water Use

2. **International Joint Commission and River Treaties**
   - Boundary Waters
   - Columbia River, etc.

3. **Dam Safety Historically Managed by Large Dam Owners Due Diligence**

Regulated Provinces

4. Provinces with Dam Safety Regulations

4. Alberta, Quebec, British Columbia
5. Ontario – Draft Regulations Proposed (Lakes & Rivers Improvement Act - in place)

5. Provinces without Dam Safety Regulations

4. Newfoundland, Nova Scotia, New Brunswick, Manitoba, Saskatchewan and the Yukon have acknowledged that they would direct dam owners/ consultants to CDA Guidelines for practice.

6. Canadian Dam Association

4. Dam Safety Guidelines (1995, 1999)
5. No force of regulation but valuable guide to practioners
6. Dam Safety Guidelines released in 2007

Regulated Provinces

Alberta and Quebec

Water Act, **Alberta Regulation 205/98 and Dam and Canal Safety Guidelines T/444**

O.C. 300-2002 *Dam Safety Act*

- **Traditional standards based approach to dam safety decision making**
- **Dam Classification System (Alberta – 4, Quebec – 6)**
- **Design Criteria (IDF, Seismic) assign to each class**
- **Uncertainty accounted for by**
  - **Conservative (extreme) loads**
  - **Conservative (low) resistance variables**
  - **Safety factors on outputs**

Regulated Provinces

British Columbia

***Water Act,* B.C. Regulation 44/2000**

- Dam Classification System (4 classes)
- Absence of specific Design Criteria (IDF, Seismic)
- Schedule of Dam Safety Reviews
  - Hazardous conditions
  - Suspension of operation
  - Expert opinion
- Frequency of Inspections and Reviews

Regulated Provinces

Ontario

Lakes and Rivers Improvement Act (LRIA), Ontario Regulation 454/96 and 1999 Draft Ontario Dam Safety Guidelines

- Traditional standards based approach to dam safety decision making
- Dam Classification System (4 classes)
- Design Criteria (IDF, Seismic) assign to each class
- Uncertainty accounted for by
  - Conservative (extreme) values for loads
  - Conservative (low) values for resistance variables
  - Conservative safety factors on outputs

Major revision of current regulation under way

Ontario – considered changes

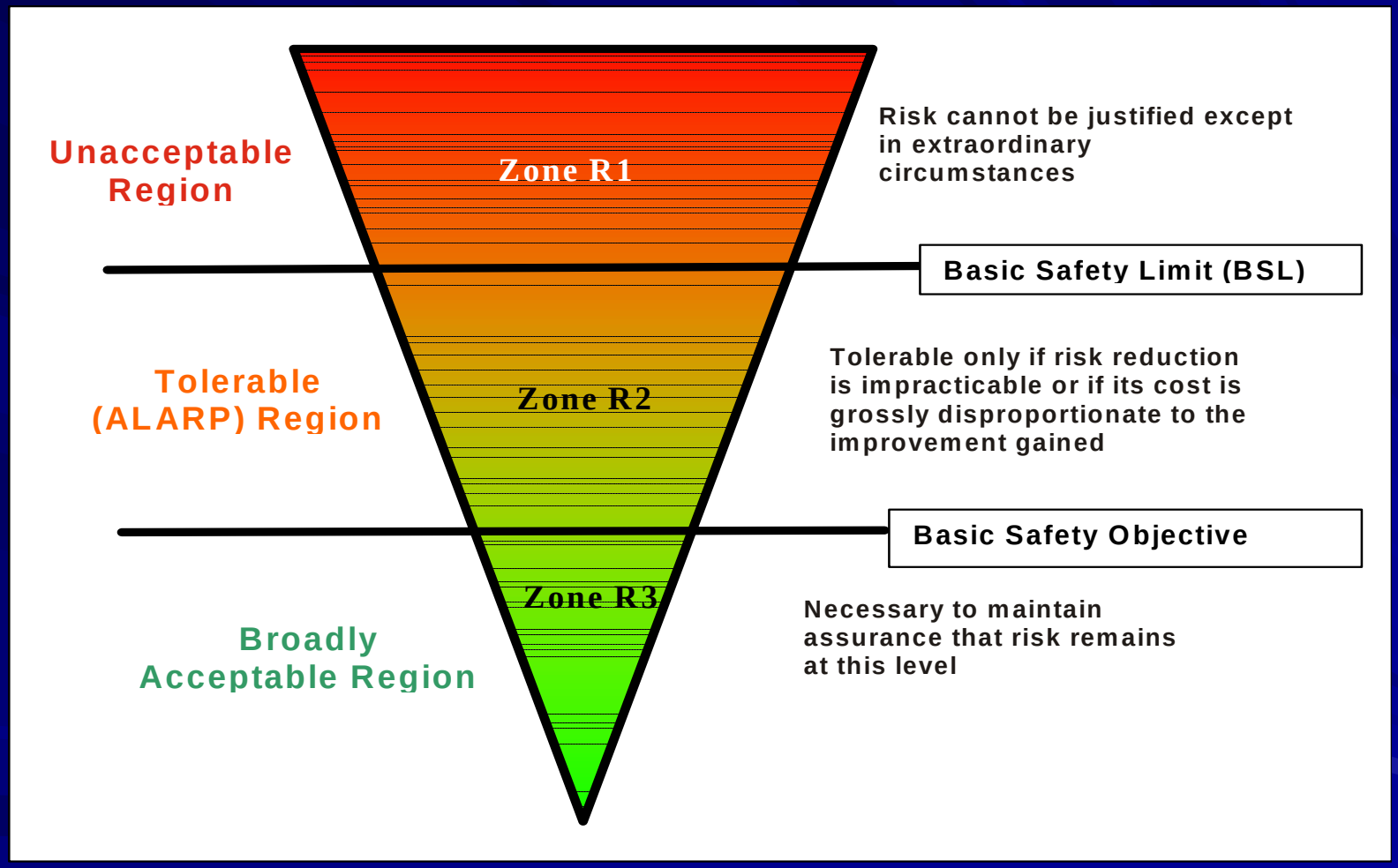
- Dam Registry
- Dam Safety Program
- Dual Approach to Dam Safety Assessment and Decision-Making
  - Traditional approach based on classification and design standards
  - Risk-informed approach based on safety case philosophy and explicit risk criteria

Ontario – considered changes

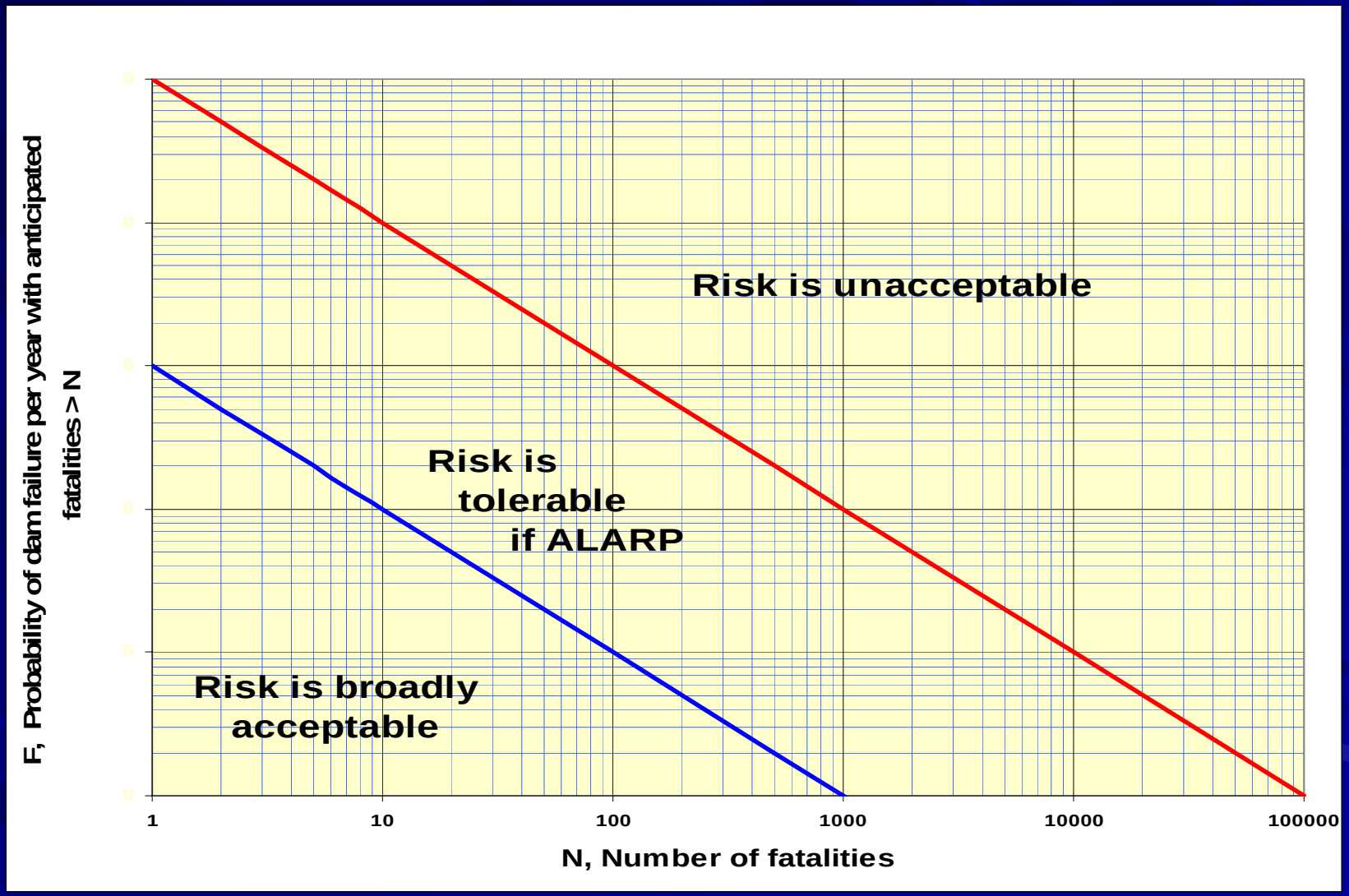
Risk Criteria

- Individual risk (life safety)
- Societal risk (life safety)
- ALARP Principle for risks that are not unacceptable
- 3rd party damages
- Environmental impacts

Ontario – considered changes



Ontario – considered changes



CDA Guidelines 2007

- **Sole or major source of guidance in all non-regulated jurisdictions in Canada**
- **Alberta**
- **British Columbia**

CDA Guidelines 2007

- Guidelines
  - Principles
  - Dam Safety Management
  - Operation, Maintenance and Surveillance
  - Emergency Preparedness
  - Dam Safety Review
  - Analysis and Assessment
- 9 Technical Bulletins

CDA Guidelines 2007

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  - Dam Safety Analysis and Assessment

CDA Guidelines 2007

Guidelines - Principles Section

1st Principle

The public and the environment shall be protected from the effects of dam failure, as well as release of any or all of the retained fluids behind a dam, such that the risks are kept as low as reasonably practicable

Formal recognition that:

- **Dam safety management is *de facto* management of risks associated with dams**
- **Established conservative practice (rules and requirements adjusted upwards when hazards or consequences of failure are greater) provides protection that may be assumed to be ALARP**

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Guidelines – Analysis and Assessment Section

Safety management should ultimately provide the answers to the following 3 questions:

- **What can go wrong?**
- **What is the likelihood (probability) of that happening?**
- **What are potential consequences?**

RISK (as a measure characterizing both the likelihood of an unwanted event and the consequences of such an event) can be used as performance goal to demonstrate that required levels of safety are met.

Tolerability of risk is fundamentally a matter of political choices and political value judgments.

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Guidelines – Analysis and Assessment Section

INDIVIDUAL RISK (considered in terms of 'maximally exposed individual' that is permanently resident downstream of the dam) should generally be less than 10^{-4}

SOCIETAL RISK refers to hazards that, if realized, could impact society and cause socio-political response.

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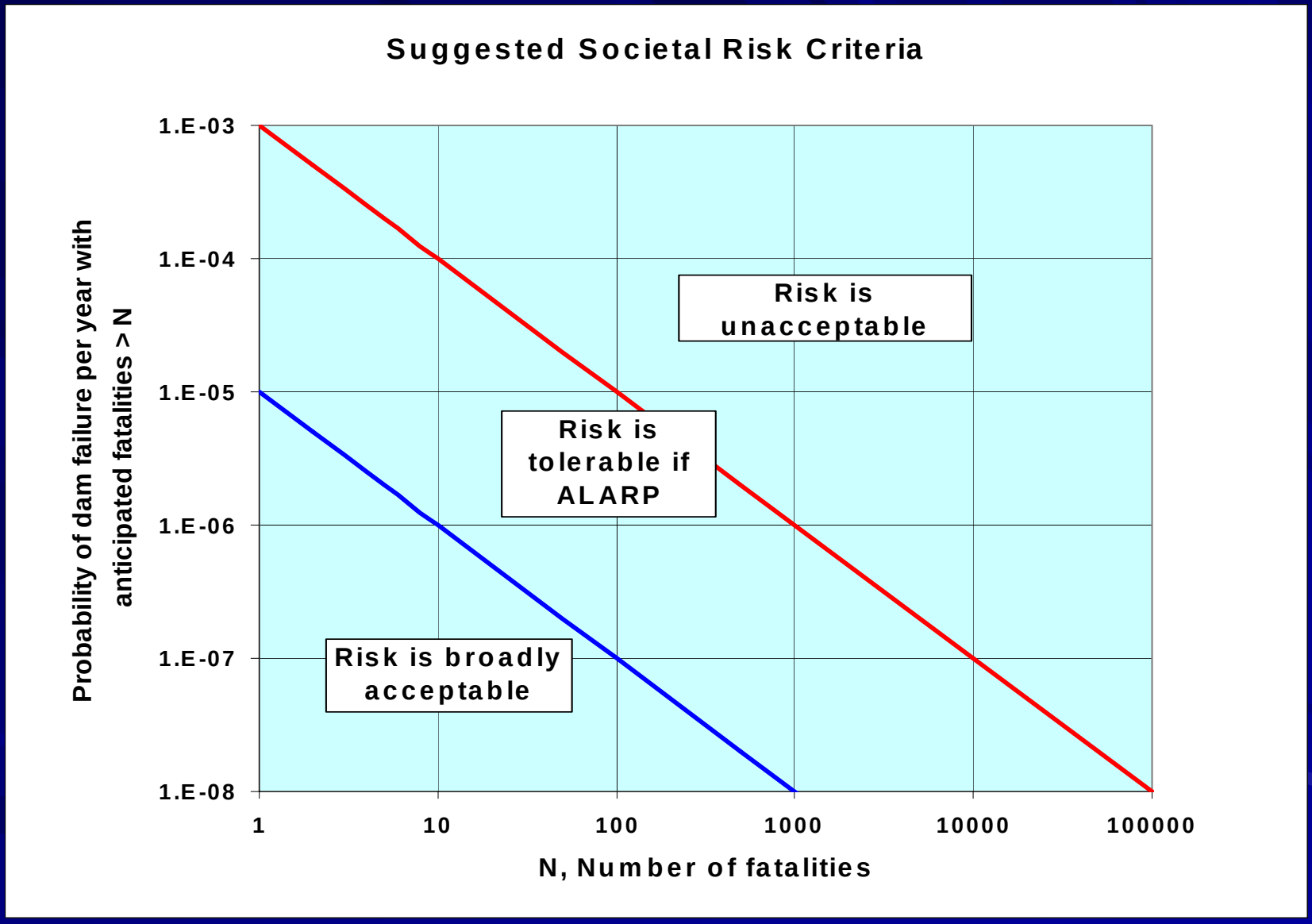

CDA Guidelines 2007

Technical Bulletin – Dam Safety Analysis and Assessment Section

General Framework that allows dam safety decisions to be made on the basis of suggested risk criteria

Background for dam safety decision-making explicitly taking into account impact of uncertainty

SUMMARY

- Recognition and endorsement of risk-based approach to assessing safety of dams and to decision-making at the national level (CDA)
- Consideration for dual approach (traditional and risk-based) to regulation of dam safety in Ontario
- Inclusion of risk-informed arguments in regulation of dam safety in British Columbia